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# Risk Factors Associated with Farm Injuries in Canada

1991 to 2001

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**Symbols**

The following standard symbols are used in Statistics Canada publications:

| | |
|---|---|
| . | not available for any reference period |
| .. | not available for a specific reference period |
| ... | not applicable |
| 0 | true zero or a value rounded to zero |
| 0[s] | value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded |
| [p] | preliminary |
| [r] | revised |
| x | suppressed to meet the confidentiality requirements of the *Statistics Act* |
| [A] | excellent |
| [B] | very good |
| [C] | good |
| [D] | acceptable |
| [E] | use with caution |
| F | too unreliable to be published |

## Abstract

Data from Canada's 2001 Census of Agriculture were used to identify factors that influence the probability that a farmer suffered a non-fatal injury from farm activities in the previous 12 months. The study is based on the weighted data of 274,797 farm operators. These data are described and analyzed using logistic regression and odds ratio analysis. The results show that men under 55 years of age who are the primary operator of the farm and who work fewer than 40 hours per week on the farm are more likely than others to sustain an injury. The quantity of some production units, such as beef cattle and area under cultivation, is positively related to the probability of injury, whereas the quantity of others, such as dairy cattle and hogs, has no significant effect. Farm receipts appear to be inversely related to the risk of injury.

## Introduction

Agriculture is one of the industries with the highest rates of fatal injury. From 1991 to 1995, that rate varied between 14.9 and 25.6 per 100,000 workers in Canada (Pickett et al., 1999). These rates approach the average rates observed during the same period in the United States (18.4) and Australia (19.4) (Ibid). Agricultural production thus ranks as the fourth most dangerous sector, behind mining, forestry and construction (which averaged, during the same period, fatal injury rates of respectively 71.0, 62.0 and 31.0 per 100,000 workers) (Ibid). With regards to non-fatal injuries among agricultural producers, studies indicate that annual frequencies are generally in the range of 5% to 10% of the population.

In recent years, the average age of Canadian farm operators has been increasing. According to census data from 1991, 1996 and 2001, the proportion of producers under 35 years of age gradually declined (from 19.9% to 15.8% to 11.5% respectively), while the proportion of producers aged 55 and over increased (from 32.1% to 32.3% to 34.9%). This trend is also reflected in the change over time in the average age. In the 1991 Census of Agriculture, the average age of Canadian farm operators was 47.5; this value rose to 48.3 and 49.9 in the 1996 and 2001 censuses respectively.

This aging pattern suggests that health issues might become increasingly frequent within the farm population. Several studies have shown that if a farmer has a diagnosis of arthritis, rheumatism, hearing problems or a loss of visual acuity, there is an increased risk of agricultural injuries (McCurdy and Carroll, 2000; Browning et al., 1998; Lewis et al., 1998). Hansen (1986) also showed that older producers tend to use older machinery that often lack safety devices. Furthermore, reduced reflex speed may make older producers more susceptible to injury (Etherton et al., 1991). Since there is no mandatory retirement age in farming, and since the intergenerational transfer of farms tends to extend over a number of years, many farmers continue to perform various tasks beyond the age at which they have the ability to do so safely.

To optimize the results of farm safety preventive measures, it would be useful to be able to target individuals who are more likely to be injured when engaged in farming activities. This analysis will examine the relationship between the probability of suffering an agricultural injury and the characteristics of the farm and its operator. This study seeks to provide indications to decision-makers to maximize the effectiveness of programs to reduce and prevent work injuries in the agricultural sector. It will also identify various factors that may influence the probability of accidents.

## Methodology

### Data source

The data used for this study is the 2001 Census of Agriculture. Farms with gross farm receipts of less than $10,000 were excluded due to their small size, leaving 274,797 farmers in the analysis. Each person responsible for making decisions related to the daily management of the agricultural operation was considered, up to a maximum of three operators per farm. The census question used for information concerning the operator's injury was, "In the last 12 months, did this operator suffer a farm-related injury that required medical care or resulted in lost work time?" If the respondent answered yes, the type of injury was recorded.

### Logistic regression model

This model assumes that at least one characteristic of the operator or farm influences the probability that the operator will suffer an injury. The logistic regression model will serve to investigate the relationship between the risk of injury and the independent variables selected (i.e., characteristics of the farm and its operator). This model allows the computation of odds ratios which make the understanding of this relationship easier. These characteristics are outlined in the next section, along with the reasons for their inclusion in the model.

A logistic regression model[1] is designed to estimate the parameters of a multiple regression analysis in which the dependent variable is nominal. In the present case, this variable is dichotomous; it takes the value 1 if the operator suffered an injury during the past twelve months and 0 if this is not the case.

This model expresses the conditional probabilities that an operator $i$ will suffer an injury during the year as a linear function of a set of independent variables. The model is represented as follows:

$$\text{Log}\left[\frac{\hat{Y}_i}{(1-\hat{Y}_i)}\right] = \alpha + \sum_{k=1}^{K} \beta_k X_{ik} + \varepsilon_i$$

1. For more information on this model, see Greene (2003).

where $\hat{Y}_i$ is the estimate of the conditional probability that an operator $i$ will suffer an injury (i.e. that $P(Y_i) = 1$) according to the independent variables of the model. Consequently, $1 - \hat{Y}_i$ is the conditional probability that an operator $i$ will not suffer an injury. The ratio $(\hat{Y}_i)/(1-\hat{Y}_i)$ is the odds or the relative probability of being in one of these two situations. The coordinate at the origin $\alpha$ and the coefficients $\beta$ associated with each of the independent variables are the elements of the logistic regression to be estimated; $X_{ik}$ represents the independent variable $k$ associated with operator $i$ of the sample; and $\varepsilon_i$ is the random residual associated with operator $i$. The relative probability that operator $i$ will suffer an injury can be calculated by exponentiating the previous equation. All statistical analyses were carried out using the SAS statistical software package.

**Independent variables**

The choice of independent variables used in the regression is based on a review of the literature, the availability of data and an analysis of correlation between the variables selected (see table of Pearson coefficients, appended). The following highlights the independent variables used in the analysis.

1. Sex

According to all the studies consulted, the risk of farm-related injury is greater for men than for women (Ferguson et al., 1999; Hagel et al., 2004; Stallones and Beseler, 2003; Virtanen et al., 2003; Hwang et al., 2001; McCurdy and Carroll, 2000; Pickett et al., 1999). Some studies show that the difference is greater when the duration of exposure to farm work is taken into account (Miller et al., 2004; McCurdy and Carroll, 2000). Other studies tend to show the opposite (Ferguson et al., 1999). In the present study, it is not possible to disaggregate the data in this way because the number of hours worked on the farm is not a continuous variable but is only defined according to three categories. However, it seems reasonable to hypothesize that male operators are more likely to have a farm injury occur.

2. Age

Age may influence the probability of injury. It can be a proxy datum for several factors such as general health status, cumulative experience, tendency to take risks, reflex speed, visual acuity and hearing. Age may also be related to certain risk factors. For example, Hansen (1986) suggests there may be a link between age and the probability of using tractors that are not equipped with safety devices or are near the end of their useful life.

Regarding the influence of age on the probability of injury, the findings are mixed. Studies have shown that among operators and farm workers, both the youngest and oldest age groups are more likely to suffer injuries (Hagel et al., 2004; Sprince et al., 2002, 2003a, 2003b, 2003c; McCurdy and Carroll, 2000; Lewis et al., 1998; Lyman et al., 1999; Pickett et al., 1999). It would appear that the risk of a fall is higher among older producers (Hagel, 2004; Sprince, 2003c), whereas those in the younger group are more

likely to have machinery-related injuries (Hagel, 2004; Sprince, 2002). From these studies, the expectation is that both the younger and the older farm operator groups are more susceptible to farm injury.

3. Operator's rank

Since the operator's rank is a proxy datum for exposure to farm work, it seems likely that this variable will correlate with the probability of suffering an injury. According to the literature reviewed by McCurdy and Carroll (2000), the risk of injuries is three times greater for the primary operator than for other operators. As regards fatal injuries, the Canadian Agricultural Injury Surveillance Program reports that 60.2% of fatal injuries are sustained by the primary operator (Pickett et al., 1999). Studying risk factors for injuries on Ontario farms, Simpson et al. (2004) also found that the primary operator is more likely to suffer an injury. The effect of the operator's level of responsibility may be related to the fact that this variable is also a proxy for farming-related stress. Some studies find that this factor is positively correlated with the probability of farm injury (Sprince et al., 2002; Geller, 1990).

4. Number of hours per week worked on farm

The number of hours worked on the farm may be a proxy datum for factors such as risk exposure, fatigue and experience, which may have opposite effects. According to the literature, the probability of injury is greater for individuals working full-time on the farm (Sprince et al., 2002; McCurdy and Carroll, 2000; Lewis et al., 1998). The number of hours worked may therefore be expected to be positively related to farm injury. Since the available data distinguish only one category of producers who work more than 40 hours per week, it is unlikely that the results would show that beyond a certain threshold fatigue offsets the effect of technical expertise and the probability of injury increases. The existence of such a threshold has been demonstrated in the literature. For example, Sprince et al. (2002 and 2003a) showed that operators working more than 50 hours per week were more likely to have suffered an injury during the past twelve months. Ferguson et al. (2005) found this same relationship when studying how a binary variable identifying producers working 61 to 80 hours per week affected the probability that the producer had been involved in a tractor accident.

5. Off-farm work

According to the literature, producers who have an off-farm job tend to have fewer injuries (Simpson et al., 2004; Sprince et al., 2003b and 2002). Since the duration of off-farm work is inversely proportional to the time of exposure to farm work, it is likely this variable will be negatively associated with the probability of injury in the performance of farm tasks.

6. Farm type and presence of livestock

Farm animals are one of the main causes of farm injuries (Pickett et al., 1999). The literature tends to show that the presence of animals in general and cattle in particular increases the probability of injury (Sprince et al., 2003a; Hwang et al., 2001; Browning et al., 1998; Zhou and Roseman, 1994). According to the studies reviewed by McCurdy and Carroll (2000), the risk of injury for farm workers engaged in beef and dairy production is twice the average for other types of production. Virtanen (2003) also observed this relationship, and his analysis stresses that the risk of injury is proportional to the number of dairy cows. Using the number of injuries per 100,000 hours worked as a dependent variable, Miller et al. (2004) showed that working with horses was one of the main risk factors. The variables that will be used in this study to estimate the effect of the presence of animals include farm type, number of dairy cows, number of beef cattle and number of hogs. It is expected that cattle and dairy farm operators will be more subject to injury and that risk will rise with herd size.

7. Farm size

The literature tends to show that farm size increases the probability of farm-related injury (McCurdy and Carroll, 2000). For example, Browning et al. (1998) showed that farm operators with farm receipts exceeding $40,000 have a higher risk of injury. Using cultivable area as a proxy variable for farm size, Virtanen et al. (2003) noted that this risk is greater for workers on farms with between 49 and 245 cultivable acres. Hoskin et al. (1988) showed that the relative probability of injury was 25% higher for farms with 49 acres or more of cultivable area. In the present study, gross farm receipts and area under cultivation will be used as proxy variables for farm size. It is expected that these variables will have a positive effect.

8. Weeks of on-farm paid work

Studies have shown that farm injury cases were more frequent on farms where hired labour worked twelve weeks or more on the farm per year (Sprince et al., 2003a and b). The present analysis will test if the effect of employing paid labour for twelve weeks or more per year on the farm results in a positive probability of farm injury.

**Description of dependent variable**

Only 3.5% of respondents stated they had suffered a farming-related injury during the twelve months preceding the census. This frequency is less than that observed in most existing studies. In a review of farm safety surveys, McCurdy and Carroll (2000) reported injury incidence rates ranging from 0.5% to 16.6% per year, with an average rate generally ranging between 5% and 10%. Therefore, the injury rates reported here seem relatively low.

The table below describes the types of farm injuries reported by farm operators and their frequency. It appears that nearly two injuries in five are fractures (20.70%) or open wounds (19.79%). The majority of farm injuries (51.95%) are musculoskeletal (i.e. fractures, dislocations, sprains/strains, and back injuries).

**Table 1 Agricultural injuries reported by farm operators, Canada, 2001Percentage**

| Type of injury | Number of injuries | of injuries |
|---|---|---|
| Multiple injuries | 386 | 4.01 |
| Fractures | 1,991 | 20.70 |
| Dislocations | 242 | 2.52 |
| Sprains and strains | 1,359 | 14.13 |
| Open wounds | 1,903 | 19.79 |
| Crush injury | 527 | 5.48 |
| Foreign body in ear, eye, nose or mouth | 361 | 3.75 |
| Head injuries | 138 | 1.43 |
| Burns | 110 | 1.14 |
| Internal injuries | 39 | 0.41 |
| Back injuries | 1,403 | 14.59 |
| Poisonings | 81 | 0.84 |
| Physical condition unrelated to trauma | 453 | 4.71 |
| Other injuries | 624 | 6.49 |
| Total | 9,617 | 100.00 |

**Source**: Statistics Canada, Census of Agriculture, 2001.

## Limitations

There may be several reasons why cases of farm injuries are not all counted. One such reason is that the recall period is twelve months. Harrell (1995) and Landen and Hendricks (1995) showed that recent injuries are more likely to be reported than those that were caused a number of months before the survey. It was also shown that farmers tend to feel that injuries are part of their line of work and are reluctant to report them in surveys (Cummings, 1992).

It should be noted that the census question does not allow a respondent to report more than one injury and only the injuries of operators responsible for the daily management of the farm are reported. Therefore, the study does not take into account the injuries of farm workers or individuals not responsible for the farm.

## Results

### Descriptive statistics

The results of the analysis are described in Table 2. Reported injury cases are more frequent for men (4.04%) than for women (1.89%). Operators aged 66 and over have a slightly lower percentage of injuries (2.95%) than other age classes, which have fairly similar injury frequencies (varying between 3.23% and 3.76%). In 2001, a larger proportion of primary farm operators (4.13%) suffered a farm injury than second- and third-ranking operators (respectively 2.00% and 2.42%). Operators working on their farm fewer than 20 hours per week appear to injure themselves more frequently than those working more hours. Operators working off the farm for more than 40 hours per week are more likely to injure themselves than those devoting less time to this type of employment.

Regarding the impact of farm characteristics, farms specialized in horses, forestry products and cattle production have higher percentages of injury cases (respectively 4.52%, 4.21% and 4.19%). Conversely, fruit and vegetable producers and poultry producers have lower rates of injury than other types of farms (respectively 2.14% and 2.24%).

The proportion of injured operators does not increase steadily with the increase in the number of dairy cattle. However, it does as the size of beef cattle herds rise. For hog producers, injury rates reach a maximum of 4.39% for herds of 101 to 500 hogs, subsequently falling off as the number of hogs increases.

The two proxy variables for farm size, which include acreage and gross sales, show that operators working on smaller farms have relatively fewer injuries. Frequencies of injury cases among operators of farms with 70 cultivable acres and under and those with gross farm receipts of $50,000 and under are the lowest for these variables (respectively 2.85% and 2.90%).

In regards to labour intensity, it appears that operators of farms using twelve weeks of paid labour or more have a slighter higher injury rate than others (3.72% versus 3.37%). Because of the large number of observations, the standard error on the results is fairly low.

**Table 2 Farm operator injury cases, Canada, 2001**

| | Number of operators | Number of injury cases | Percentage of injured operators | Standard error percentage |
|---|---|---|---|---|
| **Total number of operators** | 274,797 | 9,617 | 3.50 | --- |
| **Sex** | | | | |
| Male | 205,918 | 8,315 | 4.04 | 0.0430 |
| Female | 68,879 | 1,302 | 1.89 | 0.0517 |
| **Age**[1] | | | | |
| 25 and under | 6,876 | 222 | 3.23 | 0.2119 |
| 26 to 35 | 31,099 | 1,114 | 3.58 | 0.1045 |
| 36 to 45 | 75,084 | 2,823 | 3.76 | 0.0688 |
| 46 to 55 | 76,025 | 2,734 | 3.60 | 0.0671 |
| 56 to 65 | 50,903 | 1,697 | 3.33 | 0.0792 |
| 66 and over | 34,810 | 1,027 | 2.95 | 0.0903 |
| **Operator's rank** | | | | |
| Primary | 191,737 | 7,919 | 4.13 | 0.0452 |
| Second | 73,973 | 1,478 | 2.00 | 0.0511 |
| Third | 9,087 | 220 | 2.42 | 0.1588 |
| **Average number of hours per week worked on farm** | | | | |
| Fewer than 20 | 153,550 | 7,051 | 4.59 | 0.0531 |
| 20 to 40 | 70,955 | 1,886 | 2.66 | 0.0600 |
| More than 40 | 50,292 | 680 | 1.35 | 0.0511 |
| **Average number of hours per week worked off farm** | | | | |
| None | 166,114 | 6,443 | 3.88 | 0.0471 |
| Fewer than 20 | 39,866 | 987 | 2.48 | 0.0771 |
| 20 to 40 | 44,952 | 1,282 | 2.85 | 0.0779 |
| More than 40 | 23,865 | 905 | 3.79 | 0.1227 |
| **Farm type** | | | | |
| Cattle (beef) | 81,409 | 3,412 | 4.19 | 0.0699 |
| Dairy | 31,552 | 1,213 | 3.84 | 0.1078 |
| Hog | 10,351 | 340 | 3.28 | 0.1732 |
| Poultry and egg | 5,534 | 124 | 2.24 | 0.1960 |
| Sheep, lamb and goat | 3,247 | 116 | 3.57 | 0.3251 |
| Horse and pony | 9,165 | 414 | 4.52 | 0.2162 |
| Other livestock specialties | 4,032 | 129 | 3.20 | 0.2757 |
| Livestock combination | 93,313 | 2,830 | 3.03 | 0.0557 |
| Field crop | 21,089 | 541 | 2.57 | 0.1082 |
| Fruit and vegetable | 5,828 | 125 | 2.14 | 0.1880 |
| Forest products | 5,339 | 225 | 4.21 | 0.2742 |
| Other | 3,938 | 148 | 3.76 | 0.3009 |
| **Number of dairy cattle** | | | | |
| None | 238,843 | 8,228 | 3.44 | 0.0371 |
| 1 to 15 | 3,442 | 153 | 4.45 | 0.3505 |
| 16 to 30 | 5,499 | 201 | 3.66 | 0.2523 |
| 31 to 45 | 10,406 | 436 | 4.19 | 0.0196 |
| 46 to 60 | 7,086 | 286 | 4.04 | 0.2330 |
| More than 60 | 9,521 | 313 | 3.29 | 0.1820 |

**Table 2 Farm operator injury cases, Canada, 2001** (concluded)

| | Number of operators | Number of injury cases | Percentage of injured operators | Standard error percentage |
|---|---|---|---|---|
| **Number of beef cattle** | | | | |
| None | 167,040 | 4,974 | 2.98 | 0.0413 |
| 1 to 25 | 38,017 | 1,306 | 3.44 | 0.0930 |
| 26 to 50 | 28,252 | 1,195 | 4.23 | 0.1193 |
| 51 to 100 | 23,438 | 1,128 | 4.81 | 0.1391 |
| 101 to 150 | 9,032 | 489 | 5.41 | 0.2368 |
| More than 150 | 9,018 | 525 | 5.82 | 0.2449 |
| **Number of hogs** | | | | |
| None | 255,018 | 8,860 | 3.47 | 0.0360 |
| 1 to 100 | 6,913 | 291 | 4.21 | 0.2408 |
| 101 to 500 | 4,258 | 187 | 4.39 | 0.3122 |
| 501 to 1,000 | 2,799 | 105 | 3.75 | 0.3550 |
| More than 1,000 | 5,809 | 174 | 3.00 | 0.2211 |
| **Area under cultivation (acres)** | | | | |
| 70 and under | 69,897 | 1,995 | 2.85 | 0.0626 |
| 71 to 400 | 119,553 | 4,120 | 3.45 | 0.0525 |
| 401 to 760 | 37,743 | 1,526 | 4.04 | 0.1007 |
| 761 to 1,600 | 30,584 | 1,282 | 4.19 | 0.1137 |
| More than 1,600 | 17,020 | 694 | 4.08 | 0.1502 |
| **Gross farm receipts[2] ($)** | | | | |
| $50,000 and under | 104,049 | 3,016 | 2.90 | 0.0517 |
| $50,001 to $250,000 | 115,810 | 4,642 | 4.01 | 0.0573 |
| $250,001 to $500,000 | 34,279 | 1,323 | 3.86 | 0.1032 |
| More than $500,000 | 20,659 | 636 | 3.08 | 0.1189 |
| **Number of weeks of paid work performed on farm ($)** | | | | |
| Fewer than 12 | 176,050 | 5,939 | 3.37 | 0.0428 |
| 12 or more | 98,747 | 3,678 | 3.72 | 0.0598 |

1. Age of operator on May 15, 2001.
2. Total gross farm receipts in 2000 (calendar year) or for last complete accounting (budgetary) period, including sales of forest products.

**Note**: Coefficients of variation for all frequencies lie between 0.00% and 4.99%.
**Source**: Statistics Canada, Census of Agriculture, 2001.

## Estimation of logistic regression model

The estimated coefficients for the variables selected for the logistic regression are shown in Table 3.[2] The result of the chi square of the likelihood ratio rejects the null hypothesis that all estimated coefficients are equal to zero. Consequently, one or more of the selected variables would appear to be significantly linked to the probability of sustaining a farm injury.

2. Farm type and total number of hogs were not selected for the regression because of their low explanatory power.

The results show that women are less likely to suffer farm injuries. The same is true for older individuals and lower-ranking farm operators. The probability of injury declines when the number of hours worked on the farm goes per week from under 20 hours to more than 40 hours. The probability of injury appears to increase with the number of production units (i.e., the number of dairy cows, slaughter cattle and acres under cultivation) and to decrease as gross farm receipts rise. The size of the effects of the variables is easier to interpret with odds ratios, as outlined in the next section.

**Table 3 Multivariate logistic regression analysis of potential risks of farm injury, Canada, 2001**

| Independent variables | Estimated coefficients | Wald chi square | Pr > Chi square |
|---|---|---|---|
| **Intercept** | -1.6549 | 553.6028 | <.0001[2] |
| **Sex** | -0.3397 | 87.6135 | <.0001[2] |
| **Age** | -0.0719 | 68.3136 | <.0001[2] |
| **Operator's rank** | -0.3595 | 159.4802 | <.0001[2] |
| **Average hours worked per week on farm** | -0.4977 | 697.2668 | <.0001[2] |
| **Average hours worked per week off farm** | 0.0024 | 0.0477 | 0.8271 |
| **Number of dairy cattle** | 0.0281 | 9.3654 | 0.0022[2] |
| **Number of beef cattle** | 0.1200 | 275.2209 | <.0001[2] |
| **Area under cultivation (acres)** | 0.0218 | 4.4259 | 0.0354[1] |
| **Gross farm receipts ($)** | -0.0692 | 22.8529 | <.0001[2] |

1. Estimated coefficients are different from zero with a 5% confidence threshold.
2. Estimated coefficients are different from zero with a 1% confidence threshold.

**Source**: Statistics Canada, Census of Agriculture, 2001.

### Estimation of odds ratios

Odds ratios indicate the relative probability that an individual with a specified characteristic will suffer a farm injury compared to an individual with a given reference characteristic when controlling for the effects of all other characteristics. When the odds ratio values are greater than one, it means that the variable seems linked with increased chances of the farm operator suffering an injury, while values less than one show that the variable is negatively related to the chances of suffering a farm injury. Odds ratios are estimated with a 95% confidence limit. The results are shown in Table 4.

According to this estimation, male farm operators have a higher relative likelihood of suffering an injury than female farm operators. Operators aged 25 and under are proportionally more likely to injure themselves than their counterparts aged 56 and over.

The degree of farm responsibility also seems to have some influence on the likelihood of farm injury. Second- and third-ranking operators have a lower relative probability of injury than primary operators.

The relative probability of injury appears to be lower for operators who work more than 40 hours per week on their farm. Those working fewer than 20 hours per week on the

farm appear to be more than twice as likely to sustain an injury. However, operators spending fewer than 20 hours per week in a job off the farm seem to have just under one-third the relative likelihood of injury of those who spend more than 40 hours engaged in off-farm work activity. This suggests that the expertise acquired in farm work has a significant negative effect on the probability of injury.

Operators of horse and sheep farms have the highest odds ratios, while poultry producers have the lowest. This finding is consistent with one of the conclusions of the study of Miller et al. (2004), where they found working with horses is one of the activities causing the most injuries per 100,000 hours worked. It would thus appear that producers specializing in beef cattle production are not the group most likely to suffer injuries. However, the probability of injury seems to increase with the number of beef cattle. The relative chance of injury does not appear to vary constantly with the size of the dairy cattle herd. The size of the hog herd does not seem to have a significant influence on the odds ratio.

The results show that operators of farms with less than 400 acres under cultivation have an approximately one-fifth lower relative likelihood of injury than individuals responsible for farms with more than 1,600 cultivable acres. However, those operating farms with gross farm receipts exceeding $500,000 appear to have a significantly lower relative chance of having been injured during the previous year than all groups of farmers with receipts of $500,000 or less.

The relative likelihood of farm injury appears to be slightly higher for farm operators employing paid labour for twelve weeks or more per year. The quantity of manual tasks to be performed on the farm would thus seem to be positively related to the probability of injury.

**Table 4 Estimation of odds ratios for injuries of Canadian farm operators, 2001**

| Independent variables | Odds ratio (OR) | Lower limit 95% OR | Upper limit 95% OR |
|---|---|---|---|
| **Sex** | | | |
| Male | 1.44 | 1.33 | 1.56[5] |
| Female[R] | 1.00 | 1.00 | 1.00 |
| **Age**[1] | | | |
| 25 and under[R] | 1.00 | 1.00 | 1.00 |
| 26 to 35 | 1.00 | 0.86 | 1.16 |
| 36 to 45 | 0.98 | 0.85 | 1.14 |
| 46 to 55 | 0.91 | 0.79 | 1.05 |
| 56 to 65 | 0.81 | 0.69 | 0.93[5] |
| 66 and over | 0.72 | 0.62 | 0.84[5] |
| **Operator's rank** | | | |
| Primary[R] | 1.00 | 1.00 | 1.00 |
| Second | 0.64 | 0.60 | 0.70[5] |
| Third | 0.60 | 0.52 | 0.70[5] |
| **Average number of hours per week worked on farm** | | | |
| Fewer than 20 | 2.40 | 2.20 | 2.62[5] |
| 20 to 40 | 1.67 | 1.53 | 1.83[5] |
| More than 40[R] | 1.00 | 1.00 | 1.00 |
| **Average number of hours per week worked off farm** | | | |
| None | 0.95 | 0.88 | 1.02 |
| Fewer than 20 | 0.71 | 0.64 | 0.78[5] |
| 20 to 40 | 0.84 | 0.77 | 0.92[5] |
| More than 40[R] | 1.00 | 1.00 | 1.00 |
| **Farm type** | | | |
| Cattle (beef)[R] | 1.00 | 1.00 | 1.00 |
| Dairy | 1.18 | 0.92 | 1.52 |
| Hog | 0.89 | 0.71 | 1.13 |
| Poultry and egg | 0.76 | 0.63 | 0.93[5] |
| Sheep, lamb and goat | 1.26 | 1.04 | 1.53[4] |
| Horse and pony | 1.75 | 1.55 | 1.97[5] |
| Other livestock specialties | 1.17 | 0.97 | 1.41 |
| Livestock combination | 0.86 | 0.80 | 0.93[5] |
| Field crop | 0.81 | 0.72 | 0.90[5] |
| Fruit and vegetable | 0.83 | 0.69 | 1.01[3] |
| Forest products | 1.06 | 0.91 | 1.23 |
| Other | 1.03 | 0.86 | 1.22 |
| **Number of dairy cattle** | | | |
| None | 1.30 | 1.00 | 1.70[4] |
| 1 to 15 | 1.42 | 1.07 | 1.88[4] |
| 16 to 30 | 1.02 | 0.85 | 1.23 |
| 31 to 45 | 1.18 | 1.01 | 1.38[4] |
| 46 to 60 | 1.17 | 0.99 | 1.38[3] |
| More than 60[R] | 1.00 | 1.00 | 1.00 |

**Table 4 Estimation of odds ratios for injuries of Canadian farm operators, 2001** (concluded)

| Independent variables | Odds ratio (OR) | Lower limit 95% OR | Upper limit 95% OR |
|---|---|---|---|
| **Number of beef cattle** | | | |
| None | 0.63 | 0.56 | 0.71[5] |
| 1 to 25 | 0.76 | 0.67 | 0.85[5] |
| 26 to 50 | 0.84 | 0.75 | 0.94[5] |
| 51 to 100 | 0.85 | 0.76 | 0.95[5] |
| 101 to 150 | 0.92 | 0.80 | 1.04 |
| More than 150[R] | 1.00 | 1.00 | 1.00 |
| **Number of hogs** | | | |
| None | 1.03 | 0.79 | 1.36 |
| 1 to 100 | 1.14 | 0.86 | 1.53 |
| 101 to 500 | 1.19 | 0.93 | 1.51 |
| 501 to 1000 | 1.15 | 0.90 | 1.48 |
| More than 1000[R] | 1.00 | 1.00 | 1.00 |
| **Area under cultivation (acres)** | | | |
| 70 and under | 0.82 | 0.73 | 0.92[5] |
| 71 to 400 | 0.87 | 0.78 | 0.96[5] |
| 401 to 760 | 0.92 | 0.83 | 1.02 |
| 761 to 1600 | 0.94 | 0.85 | 1.03 |
| More than 1600[R] | 1.00 | 1.00 | 1.00 |
| **Gross farm receipts[2] ($)** | | | |
| $50,000 and under | 1.28 | 1.15 | 1.44[5] |
| $50,001 to $250,000 | 1.32 | 1.19 | 1.46[5] |
| $250,001 to $500,000 | 1.22 | 1.11 | 1.35[5] |
| More than $500,000[R] | 1.00 | 1.00 | 1.00 |
| **Number of weeks of paid work performed on farm** | | | |
| Fewer than 12[R] | 1.00 | 1.00 | 1.00 |
| 12 or more | 1.06 | 1.01 | 1.12[4] |

R Indicates reference category.
1. Operator's age on May 15, 2001.
2. Total gross farm receipts of the operation in 2000 (calendar year) or for the complete last accounting (budgetary) period, including sales of forest products.
3. Difference between odds ratios is significantly different from zero at a 10% confidence threshold.
4. Difference between odds ratios is significantly different from zero at a 5% confidence threshold.
5. Difference between odds ratios is significantly different from zero at a 1% confidence threshold.
**Source**: Statistics Canada, Census of Agriculture, 2001.

## Discussion

Hypotheses concerning the operator's gender and rank were tested. Men and primary operators are more likely to suffer farm injuries. It would be interesting, in a future analysis, to determine whether the significance and scope of the difference between odds ratios remains observable when the number of injuries is broken down by exposure to specific farm tasks. According to the previously cited studies, when the independent variable is broken down in this way, the gap between men and women narrows and sometimes even reverses.

The results show that operators under 35 years of age are more likely of having a farm injury and the incidence of injuries decreases with age. The study of Root (1981) concerning the risk of injury for workers in general reaches a similar conclusion. It would appear that experience and know-how have more influence on the probability of injury than does the aging process. If the available data included objective information on operators' health status, it would be possible to develop a more reliable proxy variable for this factor. Thus, it would be possible to obtain more convincing results on the influence of this particular variable on the probability of injury.

The odds ratios and regression results show that the duration of weekly work on the farm reduces the probability of a farm injury occurring. It therefore appears that the effect of greater exposure to farm work and the associated risks is more than offset by the expertise of operators devoting themselves full-time to their farm. It is plausible that the effect of this variable is not linear and that beyond a certain threshold, the effect of expertise is offset or even outweighed by the effect of fatigue. Because a single category was defined for producers working more than 40 hours, it is not possible in this study to determine whether such a threshold exists. It would have been useful to define a category identifying operators working more than 60 or 70 hours on their farm. A positive correlation between the amount of time devoted to work and the probability of injury has been observed by Ferguson et al. (2005) for producers working 61 to 80 hours per week.

Regarding the influence of off-farm work, according to the odds ratios, operators working off-farm 40 hours per week or less have a lower relative probability of injuring themselves than do producers devoting more than 40 hours per week to this type of activity. This may be a consequence of fatigue from the combination of hours worked on-farm and off-farm.

While operators specializing in dairy and beef cattle production sustain the most injuries, the results show that the likelihood of injury is higher among horse and sheep producers. For horse and sheep producers, the relative probability of injury is respectively 75% and 26% higher than for cattle producers, all things being equal. According to the odds ratios and logistic regression, it appears that the larger the size of the beef cattle herd, the greater the probability of injury. Operators working on farms specializing in field crops or poultry and egg production are less likely to incur injuries.

The fact that the size of the area under cultivation positively affects the probability of injury may be related to the fact that the probability of injury increases with exposure to machinery. It is generally recognized that machinery is one of the main causes of injury in agriculture. Coury et al. (1999) report that according to data from the Farm Accident Monitoring System, farm machinery was involved in 31% of accidents that took place on Alberta farms in 1995 and in 65% of fatal farm accidents that occurred in Alberta between 1976 and 1989.

The finding that gross farm receipts is negatively related to the probability of injury may be due to operators deriving a larger share of their income from farming activity having more know-how and more knowledge about how to prevent injury.

## Summary

According to the results of the analysis, being more than 55 years of age, working more than 40 hours per week on the farm and operating a farm whose gross sales are relatively high tend to reduce the likelihood of farm injury. Thus, experience and the relative economic importance of the farm for the operator seem to be correlated with know-how, yielding a reduction in the probability that the operator will be injured while performing farm tasks.

Being male, the primary operator, working on a farm with a sizable herd of cattle and a large area under cultivation seem to increase the risk of being injured in the course of farm work. It seems likely that these variables are correlated with exposure to the risk inherent in farm tasks. However, with the data available, it was not possible in this study to examine the probability of injury in the performance of farm tasks in relation to the degree of exposure to these types of tasks. This could be examined in a future study.

According to the present study, to optimize the effectiveness of measures to reduce and prevent injuries, the population targeted should be men under 55 years of age who work part-time on their farm; similarly primary operators of farms specializing in horse or sheep production or those who have a large cattle herd; farm operators who have more than 400 acres under cultivation; and who have gross farm receipts less than $500,000.

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## Appendix Matrix of Pearson Correlation Coefficients

| Independent variables | Intercept | Sex | Age | Operator's rank | Weekly duration of work on farm | Weekly duration of work off farm | Number of dairy cattle | Number of beef cattle | Area under cultivation | Gross farm income |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | **1.0000** | -0.3126 | -0.5799 | -0.1303 | -0.3764 | -0.1962 | -0.2516 | -0.2290 | -0.2249 | -0.3031 |
| Sex | -0.3126 | **1.0000** | -0.0564 | -0.5276 | -0.0995 | -0.0108 | 0.0415 | -0.0027 | 0.0655 | 0.0369 |
| Age | -0.5799 | -0.0564 | **1.0000** | 0.1551 | -0.0254 | 0.2041 | 0.0841 | 0.0042 | -0.0051 | 0.1004 |
| Operator's rank | -0.1303 | -0.5276 | 0.1551 | **1.0000** | -0.0954 | 0.0202 | -0.1049 | -0.0496 | -0.0418 | -0.1022 |
| Weekly duration of work on farm | -0.3764 | -0.0995 | -0.0254 | -0.0954 | **1.0000** | -0.1944 | 0.1103 | 0.1527 | 0.0828 | 0.1678 |
| Weekly duration of work off farm | -0.1962 | -0.0108 | 0.2041 | 0.0202 | -0.1944 | **1.0000** | 0.1169 | -0.0153 | -0.0004 | 0.1109 |
| Number of dairy cattle | -0.2516 | 0.0415 | 0.0841 | -0.1049 | 0.1103 | 0.1169 | **1.0000** | 0.2265 | 0.1449 | -0.2698 |
| Number of beef cattle | -0.2290 | -0.0027 | 0.0042 | -0.0496 | 0.1527 | -0.0153 | 0.2265 | **1.0000** | -0.2084 | 0.0106 |
| Area under cultivation | -0.2249 | 0.0655 | -0.0051 | -0.0418 | 0.0828 | -0.0004 | 0.1449 | -0.2084 | **1.0000** | -0.3943 |
| Gross farm income | -0.3031 | 0.0369 | 0.1004 | -0.1022 | 0.1678 | 0.1109 | -0.2698 | 0.0106 | -0.3943 | **1.0000** |

**Source**: Computation based on the Census of Agriculture, 2001.

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